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NAB LITTLE CREEK
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LETTER REPORT INTERIM RESULTS OF PHASE II SUPPLEMENTAL REMEDIAL INVESTIGATION FOR SITE 12 NAB LITTLE CREEK VA

12/3/1997

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Copy of letter sent to State ESA on 1/22/98. Official Transmittal to follow

December 3, 1997

142506.DE.DM

Mr. Scott Park
LANTNAVFACENGCOM
Attention Code 18233
Lafayette Annex, Building A
6500 Hampton Boulevard
Norfolk, VA 23511-6287

Dear Mr. Park:

Subject: CLEAN II, CTO 054
Letter Report: Interim Results of the Phase II Supplemental Remedial Investigation: Naval Amphibious Base-Little Creek Site 12

Introduction and Purpose

This letter report documents the interim results of the Phase II Supplemental Remedial Investigation (Phase II SRI) at Site 12: Exchange Laundry Disposal Area, Naval Amphibious Base (NAB) Little Creek, Virginia Beach, Virginia. The field activities conducted at Site 12 will be presented, followed by a description of the site hydrogeologic characteristics and the extent of chlorinated volatile organic compound (VOC) contamination in the groundwater, surface water, and sediment at the site. These interim results are being presented at this point in the investigation to provide a basis for discussion about whether natural attenuation can be considered as a potential remedial action at Site 12, and to determine the scope of the remainder of the Phase II SRI.

The Remedial Investigation (RI) and the Phase I SRI were completed for NAB Little Creek by Foster Wheeler Environmental Services (FWES) in November 1994 and January 1996, respectively. The Phase II SRI at NAB Little Creek is currently being conducted by CH2M HILL in order to further define the extent of contamination, potential migration pathways, and exposure pathways.

Field Activities

Field activities were performed at Site 12 in order to determine the extent of chlorinated VOC contamination in the groundwater, and canal surface water and sediment. Following

is a description of the geoprobe and preliminary well sampling activities, the surface water and sediment sampling activities, and water level monitoring.

Geoprobe and Preliminary Well Sampling

The following Geoprobe groundwater sampling was conducted at the site on October 7 and 8 to characterize the extent of contamination (see Figure 1):

- One sample (#203) at a depth of 10 feet alongside existing well LC12-GW4 to compare Geoprobe data to in-well data (a groundwater sample was collected from LC12-GW4 at the same time).
- Five locations south and west of LC12-GW4 and LC12-GW2. This included several locations in a straight line along the canal at 150 ft intervals to determine the southern extent of the chlorinated hydrocarbon plume along the canal. Geoprobe sampling continued until non-detect concentrations were reached at the planned sampling depths. Four samples (#205-#208) were collected at two depths in the water table aquifer (approximately 10 to 12 feet and 18 to 20 feet). A fifth sample (#209) was collected between the shallow wells ESE-4 and ESE-5 (12-foot-deep wells) at a depth of approximately 18 to 20 feet, in order to determine the presence of chlorinated VOC contamination at this location and depth.
- Two locations (#210 and #211) east of the known plume, between the plume and the former cleaners to define the upgradient extent of the plume. Samples were collected at 10-12 feet and 18-20 feet at each location.
- Two locations (#201 and #202) at 16- to 18-feet deep alongside the former sewer line running east-west on the north side of the Exchange Building.
- One location (#204) at 18- to 20-feet-deep next to LC12-GW3 (a 12-foot-deep well).

Samples also were collected from eight of the existing wells (ESE-4, ESE-5, LC12-GW1, -GW2, -GW3, -GW4, -GW5, and -GW6) to further characterize the current extent of the plume. Well and Geoprobe samples were analyzed in the field for chlorinated VOCs only. Approximately 50 percent of the Geoprobe samples (5 Geoprobe samples) were sent offsite for confirmatory analysis. All Geoprobe points will be surveyed using a global positioning system (GPS) for horizontal coordinates.

Surface Water Sampling, Sediment Sampling, and Water Level Monitoring

One round of surface water and sediment samples were collected from six locations within the canal to determine if contaminants are discharging into the canal (see Figure 1). Surface water samples were analyzed for chlorinated VOCs, chloride, nitrate, sulfate, total and dissolved iron and manganese, alkalinity, hardness, total organic carbon (TOC), methane, ethane, and ethene. Field measurements were made for pH, temperature, dissolved oxygen (DO), redox potential and conductivity. Sediment samples were analyzed for chlorinated VOCs, TOC, and total iron and manganese.

The first of five rounds of water level monitoring also was conducted to clarify the interactions between the groundwater and the canal. Two data loggers were set up to collect data for 2 months from a southern canal location and a northern canal location (near wells LC12-GW4 and LC12-GW9, respectively).

Results

Following is a discussion of Site 12 hydrogeologic characteristics and the extent of the chlorinated VOC contamination in the groundwater and canal surface water and sediment.

Hydrogeologic Characteristics

The groundwater elevations above mean sea level (MSL) at Site 12 are presented in Table 1 for the RI, Phase I SRI, and Phase II SRI. The groundwater contour maps developed from the data collected during the RI, Phase I SRI, and Phase II SRI are presented in Figures 2, 3, and 4, respectively. The contour maps from the RI, Phase I SRI, and Phase II SRI indicate that the groundwater flow direction under Site 12 is toward the canal.

Two data loggers were set up to collect data from a southern canal location and well LC12-GW4, and a northern canal location and well LC12-GW9 between September 17 and November 7, 1997 to clarify the interactions between the groundwater and the canal. The data logger graphs for the southern and northern gaging stations are presented in Figures 5 and 6, respectively. The data indicate that during all but 7 of the 50 days of data collection, groundwater is recharged from the canal. The 7 days during which groundwater is discharged to the canal correspond to long periods of no rainfall. As a result, it appears that during most periods, the groundwater flow in the east side of the canal flows west toward the canal and then south along the canal, as the canal acts as a hydraulic barrier.

The groundwater level data collected by ESE on the west side of the canal (2 rounds in July and September 1995) indicate that there is a slight gradient to the northwest, away from the canal. However, the gradient is so slight (only 0.1 feet over 300 feet) that it essentially is flat. Groundwater elevations collected in this same area by Applied Environmental in October 1992 shows a much more significant gradient to the southeast (toward the canal).

The water level data collected during the Phase II SRI indicate that the water table on the west side of the canal is on average two feet higher than the water table on the east side of the canal and the surface water in the canal. This is most likely due to an error in surveying the wells when they were installed, either on the west or east side of the canal since they were installed and surveyed under separate projects. This potential discrepancy will be investigated when the proposed new wells are installed and surveyed.

Groundwater Analytical Results

As a result of the Phase II SRI Geoprobe investigation, the groundwater contamination plume has been defined to the north, to the west (across the canal) and to the south of Site

12. Chlorinated VOCs were not detected above the sample detection limits in the groundwater samples collected to the north of the Commissary Building and to the west of the canal nor to the south of Amphibious Drive. The highest concentrations of chlorinated VOCs were detected in the groundwater samples collected from the northeast corner of the parking lot (wells LC12-GW2 and LC12-GW5). The maximum concentration of total chlorinated VOCs was detected in well LC12-GW5, at a concentration of 13,643 µg/L. Tetrachloroethene (PCE) was detected at 13,600 µg/L in this well. A total chlorinated VOC concentration of 67.1 µg/L was detected in well LC12-GW4, adjacent to the east side of the canal. Field lab data is presented in Appendix A. Five Geoprobe samples also were sent to an offsite laboratory for confirmatory analyses. Off site laboratory confirmatory results showed slightly lower concentrations than the field laboratory results. For example, the field lab results for the Geoprobe sample GP-210-05 indicated 183 µg/l of PCE, 21 µg/l of cis 1,2 -DCE, and 2.2 µg/l of TCE. The off site laboratory results for this same sample showed 130 µg/l of PCE and less than 1 µg/l of cis 1,2-DCE and TCE. These results also are provided in Appendix A. Plume maps based on the field laboratory data are presented for total chlorinated volatiles, PCE, trichloroethene (TCE), and cis-1,2-dichloroethene in Figures 7, 8, 9, and 10, respectively.

VOC ↓
GW1
GW3

Groundwater samples also were collected during the RI (June 1993) and Phase I SRI (August 1995). A comparison of results from the three rounds of sampling show that the concentrations of total chlorinated VOCs have been decreasing over time in the groundwater samples collected from wells LC12-GW1 and LC12-GW3. The concentrations of total chlorinated VOCs have been increasing over time in the groundwater samples collected from the well LC12-GW5 (the concentration of PCE increased from 1600 µg/L to 13600 µg/L and the concentration of TCE increased from approximately 26 µg/L to 43 µg/L) and LC12-GW6 (the concentration of TCE increased from 12 µg/L to 26 µg/L).

VOC ↑
GW5
GW6

The concentrations of total chlorinated VOCs in the groundwater samples collected from wells LC12-GW2 and LC12-GW4 varied widely over the three sampling events and did not show a distinct trend with time. The combined concentrations of PCE and TCE in the samples collected from well LC12-GW2 went from 7,200 µg/L during the RI to nondetect during the Phase I SRI, to 572 µg/L during the Phase II SRI. The combined concentrations of PCE and TCE in the samples collected from well LC12-GW4 was 4 µg/L during the RI, increased to 1,550 µg/L during the Phase I SRI, and then decreased to 2.1 µg/L during the Phase II SRI. The concentration of vinyl chloride decreased from 980 µg/L to nondetect from the Phase I SRI to the Phase II SRI in this well. Potential explanations for these inconsistencies over time include: a mix up in data between the two wells during the Phase I SRI, or several different release events and extremely high groundwater flow rates.

The groundwater analytical results from groundwater wells for the RI, Phase I SRI, and Phase II SRI are presented in Table 2. Plume maps are presented in Appendix B for the chlorinated VOCs detected during the RI and Phase I SRI.

Surface Water and Sediment Analytical Results

One round of surface water and sediment samples were collected from six locations within the canal to determine if contaminants are discharging into the canal. Chlorinated VOCs were not detected above the sample detection limits in either the surface water or sediment samples. Methane was detected at a relatively high concentration (3,500 µg/L) in one surface water sample (LC12-SW204) collected on the north side of Amphibious Drive. The analytical results for surface water and sediment are presented in Table 3 and Table 4, respectively.

Future Site 12 Phase II SRI Activities

The horizontal extent of groundwater contamination (chlorinated VOCs) has been sufficiently defined and there does not appear to be any site contaminants discharging to the canal.

Based on the results from the preliminary field activities, there are no site characteristics that would eliminate natural attenuation as a potential remedial action. Natural attenuation may currently be occurring, based on the reduction in concentrations of chlorinated VOCs over time in the groundwater samples collected from selected wells.

We believe it would be appropriate for the Navy, CH2M HILL, and Virginia Tech to discuss these results and, if applicable, propose an approach for monitoring and documenting natural attenuation, and present that approach to the Virginia Department of Environmental Quality (VDEQ).

If you have any questions please do not hesitate to call me at (703) 471-6405, extension 4332.

Sincerely,

CH2M HILL

Scott J. MacEwen P.E.
Activity Manager

Jayanti Aggarwal
Environmental Engineer

cc: Ms. Kelly Greaser/NAB Little Creek
Mr. Mark Widdowson/Virginia Tech
Mr. Doug Dronfield/CH2M HILL

Tables

Table 1. Groundwater Elevations Above Mean Sea Level
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base-Little Creek
Virginia Beach, Virginia

	Remedial Investigation Date Measured: 6/28/93			Supplemental Remedial Investigation I Date Measured: 9/21/95			Supplemental Remedial Investigation II Date Measured: 9/17/97		
Monitoring Well Identification	Measuring Point Above MSL (ft)	Depth to Water Table (ft)	Water Level Above MSL (ft)	Measuring Point Above MSL (ft)	Depth to Water Table (ft)	Water Level Above MSL (ft)	Measuring Point Above MSL (ft)	Depth to Water Table (ft)	Water Level Above MSL (ft)
LC12-GW1	12.14	6.93	5.21	12.14	7.29	4.85	12.14	7.56	4.58
LC12-GW2	10.89	5.90	4.99	10.89	6.49	4.40	10.89	6.41	4.48
LC12-GW3	14.62	9.85	4.77	14.62	10.07	4.55	14.62	10.29	4.33
LC12-GW4	14.40	9.65	4.75	14.40	10.05	4.35	14.40	10.14	4.26
LC12-GW5	NA	NA	NA	11.14	6.68	4.46	11.14	6.72	4.42
LC12-GW6	NA	NA	NA	10.82	6.42	4.40	10.82	6.47	4.35
LC12-GW7	NA	NA	NA	11.17	6.79	4.38	11.17	6.89	4.28
LC12-GW8	NA	NA	NA	11.27	6.98	4.29	11.27	7.02	4.25
LC12-GW9	NA	NA	NA	15.16	10.71	4.45	15.16	10.89	4.27
ESE-3	NA	NA	NA	NA	NA	NA	14.91	8.60	6.31
ESE-4	NA	NA	NA	NA	NA	NA	14.64	8.33	6.31
ESE-5	NA	NA	NA	NA	NA	NA	13.71	7.39	6.32
CANAL SW at LC12-GW4	NA	NA	NA	NA	NA	NA	7.22	2.89	4.33
CANAL SW at LC12-GW9	NA	NA	NA	NA	NA	NA	7.25	2.90	4.35

Footnotes:

MSL: Mean sea level.
NA: Not applicable.
SW: Surface water.
ft: feet.

Table 2. Analytical Results - Groundwater
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Investigation		RI	SRI I	SRI II*	RI	SRI I	SRI II*
Sample Identification			LC12-GW1			LC12-GW2	
Sample Collection Date		6/28/93	8/95	10/7/97	6/28/93	8/95	10/7/97
ORGANICS	**Units**						
Tetrachloroethene	µg/L	ND	10 U	1 U	4900	10 U	395
Trichloroethene	µg/L	ND	2 J	1 U	2300	10 U	66
1,1-Dichloroethene	µg/L	NA	10 U	1 U	NA	10 U	111
cis-1,2-Dichloroethene	µg/L	NA	NA	1 U	NA	NA	2440
trans-1,2-Dichloroethene	µg/L	NA	NA	1 U	NA	NA	740
1,2-Dichloroethene (total)	µg/L	ND	10 U	NA	11000	10 U	NA
Vinyl Chloride	µg/L	NA	10 U	1 U	NA	10 U	1 U

Footnotes:

*: Unvalidated data (from field laboratory).
D: Sample was diluted.
J: Estimated value.
NA: Not analyzed.
ND: Compound not detected (detection limit unknown).
R: Sample was rejected.
RI: Remedial Investigation.
SRI I: Phase I Supplemental Remedial Investigation.
SRI II: Phase II Supplemental Remedial Investigation.
µg/L: micrograms per liter.
U: Compound not detected above detection limit.

Table 2. Analytical Results - Groundwater
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Investigation		RI	SRI I	SRI II*	RI	SRI I	SRI II*
Sample Identification			LC12-GW3			LC12-GW4	
Sample Collection Date		6/28/93	8/95	10/7/97	6/28/93	8/95	10/8/97
ORGANICS	**Units**						
Tetrachloroethene	µg/L	4 J	4 J	1 U	2 J	790	1 U
Trichloroethene	µg/L	2 J	1 J	3	2 J	760	2.1
1,1-Dichloroethene	µg/L	NA	10 U	1 U	NA	250 U	1 U
cis-1,2-Dichloroethene	µg/L	NA	NA	1 U	NA	NA	65
trans-1,2-Dichloroethene	µg/L	NA	NA	1 U	NA	NA	1 U
1,2-Dichloroethene (total)	µg/L	2 J	10 U	NA	ND	11000 R	NA
Vinyl Chloride	µg/L	NA	10 U	1 U	NA	980	1 U

Footnotes:

*: Unvalidated data (from field laboratory).
D: Sample was diluted.
J: Estimated value.
NA: Not analyzed.
ND: Compound not detected (detection limit unknown).
R: Sample was rejected.
RI: Remedial Investigation.
SRI I: Phase I Supplemental Remedial Investigation.
SRI II: Phase II Supplemental Remedial Investigation.
µg/L: micrograms per liter.
U: Compound not detected above detection limit.

Table 2. Analytical Results - Groundwater
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Investigation		SRI I	SRI II*	SRI I	SRI II*	SRI I	SRI I
Sample Identification		LC12-GW5		LC12-GW6		LC12-GW7	LC12-GW8
Sample Collection Date		8/95	10/9/97	8/95	10/8/97	8/95	8/95
ORGANICS	**Units**						
Tetrachloroethene	µg/L	1600	13600 D	200 R	103	580	38
Trichloroethene	µg/L	26 J	43	12	26	18 J	2 J
1,1-Dichloroethene	µg/L	100 U	1 U	10 U	1 U	50 U	10 U
cis-1,2-Dichloroethene	µg/L	NA	1 U	NA	10	NA	NA
trans-1,2-Dichloroethene	µg/L	NA	1 U	NA	1 U	NA	NA
1,2-Dichloroethene (total)	µg/L	100 U	NA	4 J	NA	15 J	10 U
Vinyl Chloride	µg/L	100 U	1 U	10 U	1 U	50 U	10 U

Footnotes:

*: Unvalidated data (from field laboratory).
D: Sample was diluted.
J: Estimated value.
NA: Not analyzed.
ND: Compound not detected (detection limit unknown).
R: Sample was rejected.
RI: Remedial Investigation.
SRI I: Phase I Supplemental Remedial Investigation.
SRI II: Phase II Supplemental Remedial Investigation.
µg/L: micrograms per liter.
U: Compound not detected above detection limit.

Table 2. Analytical Results - Groundwater
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Investigation		SRI I	SRI I	SRI II*	SRI II*
Sample Identification		**LC12-GW9**	**LC12-GW10**	**ESE-4**	**ESE-5**
Sample Collection Date		**8/95**	**8/95**	**10/9/97**	**10/9/97**
ORGANICS	**Units**				
Tetrachloroethene	µg/L	15	370 D	1 U	1 U
Trichloroethene	µg/L	10 U	16	1 U	1 U
1,1-Dichloroethene	µg/L	10 U	10 U	1 U	1 U
cis-1,2-Dichloroethene	µg/L	NA	NA	1 U	1 U
trans-1,2-Dichloroethene	µg/L	NA	NA	1 U	1 U
1,2-Dichloroethene (total)	µg/L	10 U	7 J	NA	NA
Vinyl Chloride	µg/L	10 U	10 U	1 U	1 U

Footnotes:

*: Unvalidated data (from field laboratory).
D: Sample was diluted.
J: Estimated value.
NA: Not analyzed.
ND: Compound not detected (detection limit unknown).
R: Sample was rejected.
RI: Remedial Investigation.
SRI I: Phase I Supplemental Remedial Investigation.
SRI II: Phase II Supplemental Remedial Investigation.
µg/L: micrograms per liter.
U: Compound not detected above detection limit.

Table 3. Analytical Results* - Surface Water
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Sample Identification Sample Collection Date				LC12-SW201 10/8/97	LC12-SW200** 10/8/97	LC12-SW202 10/8/97	LC12-SW203 10/8/97	LC12-SW204 10/8/97	LC12-SW205 10/8/97	LC12-SW206 10/8/97
INORGANICS	**Method**	**DL**	**Units**							
Alkalinity as $CaCO_3$	EPA 310.1	2.0	mg/L	34	34	46	55	83	23	35
Chloride	EPA 325.3	5.0	mg/L	8.86	23	14.2	12.4	10.6	5 U	10.6
Hardness as $CaCO_3$	EPA 200.7	2.0	mg/L	33	34	40	47	74	27	32
Nitrogen, Nitrate	EPA 353.2	0.05	mg/L	1.11	1.17	1.25	1.01	1.19	0.894	0.914
Nitrogen, Nitrite	EPA 353.2	0.05	mg/L	0.054	0.075	0.05 U	0.05 U	0.086	0.05 U	0.05 U
Sulfate	EPA 375.4	1.0	mg/L	7.69	6.33	2.93	4.97	10.4	9.39	1.91
Total Organic Carbon	9060	10	mg/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Iron (total)	ILM03	17	µg/L	3570	3820	2330	3100	23200	1320	2860
Iron (dissolved)	ILM03	17	µg/L	151	109	388	58.6 B	5810	85.9 B	79.8 B
Manganese (total)	ILM03	1.0	µg/L	906	1010	312	158	580	120	440
Manganese (dissolved)	ILM03	1.0	µg/L	112	93.9	94.4	112	433	24.8	81.8
ORGANICS	**Method**	**DL**	**Units**							
Methane	OLM03.0	0.2	µg/L	0.2 U	0.2 U	0.2 U	0.2 U	3500.2	0.2 U	0.2 U
Ethene	OLM03.0	2.0	µg/L	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Ethane	OLM03.0	2.0	µg/L	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Tetrachloroethene	OLM03.0	1.0	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene	OLM03.0	1.0	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	OLM03.0	1.0	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,2-Dichloroethene	OLM03.0	1.0	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	OLM03.0	1.0	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U

Footnotes:

*: Unvalidated data.
**: Duplicate of sample LC12-SW201.
B: Concentration less than the Contract Required Detection Limit but greater than or equal to the Instrument Detection Limit.
$CaCO_3$: Calcium carbonate.
DL: Detection limit.
mg/L: milligrams per liter.
NA: Not analyzed.
U: Analyte not detected above the sample detection limit.
µg/L: micrograms per liter.

Table 4. Analytical Results* - Sediment
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Sample Identification				LC12-SD201-01	LC12-SD100-01**	LC12-SD201-02	LC12-SD202-01	LC12-SD202-02
Sample Collection Date				10/08/97	10/08/97	10/08/97	10/08/97	10/08/97
Sample Depth				0-6"	0-6"	12-24"	0-6"	12-24"
INORGANICS	**Method**	**DL**	**Units**					
Total Organic Carbon	9060	4.0	mg/kg	4278	3532	10318	2541	NA
Iron (total)	ILM03	17	µg/kg	22400	19000	12800	3590	NA
Manganese (total)	ILM03	1.0	µg/kg	260	210	127	49.9	NA
ORGANICS	**Method**	**DL**	**Units**					
Tetrachloroethene	OLM03.0	6-36	µg/kg	36 U	34 U	10 U	33 U	6.1 U
Trichloroethene	OLM03.0	6-36	µg/kg	36 U	34 U	10 U	33 U	6.1 U
cis-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	36 U	34 U	10 U	33 U	6.1 U
trans-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	36 U	34 U	10 U	33 U	6.1 U
Vinyl Chloride	OLM03.0	12-72	µg/kg	72 U	68 U	20 U	66 U	12 U

Footnotes:

*: Unvalidated data.
**: Duplicate of sample LC12-SD201-01
DL: Detection limit.
mg/kg: milligrams per kilogram.
NA: Not analyzed.
µg/kg: micrograms per kilogram.
U: Analyte not detected above the sample detection limit.

Table 4. Analytical Results* - Sediment
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Sample Identification				LC12-SD203-01	LC12-SD203-02	LC12-SD204-01	LC12-SD204-02	LC12-SD205-01
Sample Collection Date				10/08/97	10/08/97	10/08/97	10/08/97	10/08/97
Sample Depth				0-6"	12-24"	0-6"	12-24"	0-6"
INORGANICS	**Method**	**DL**	**Units**					
Total Organic Carbon	9060	4.0	mg/kg	1745	3717	1590	1769	938
Iron (total)	ILM03	17	µg/kg	2420	52100	18300	18000	15200
Manganese (total)	ILM03	1.0	µg/kg	22.1	111	216	184	166
ORGANICS	**Method**	**DL**	**Units**					
Tetrachloroethene	OLM03.0	6-36	µg/kg	31 U	9.1 U	35 U	29 U	17 U
Trichloroethene	OLM03.0	6-36	µg/kg	31 U	9.1 U	35 U	29 U	17 U
cis-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	31 U	9.1 U	35 U	29 U	17 U
trans-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	31 U	9.1 U	35 U	29 U	17 U
Vinyl Chloride	OLM03.0	12-72	µg/kg	62 U	18 U	70 U	57 U	34 U

Footnotes:

*: Unvalidated data.
**: Duplicate of sample LC12-SD201-01
DL: Detection limit.
mg/kg: milligrams per kilogram.
NA: Not analyzed.
µg/kg: micrograms per kilogram.
U: Analyte not detected above the sample detection limit.

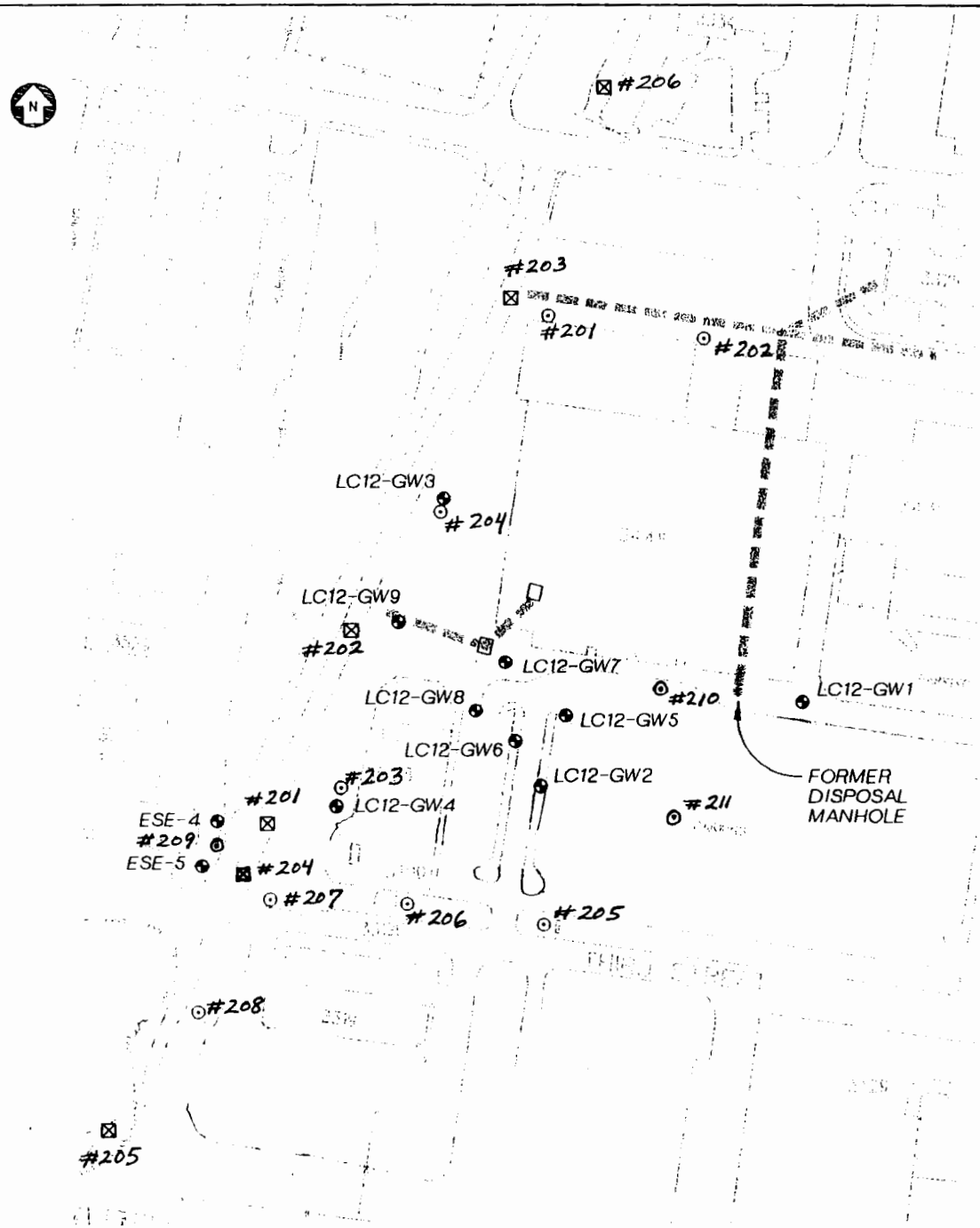
Table 4. Analytical Results* - Sediment
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

Sample Identification				**LC12-SD205-02**	**LC12-SD206-01**	**LC12-SD206-02**
Sample Collection Date				**10/08/97**	**10/08/97**	**10/9/97**
Sample Depth				**12-24"**	**0-6"**	**12-24"**
INORGANICS	**Method**	**DL**	**Units**			
Total Organic Carbon	9060	4.0	mg/kg	4938	814	8112
Iron (total)	ILM03	17	µg/kg	1340	14500	6550
Manganese (total)	ILM03	1.0	µg/kg	10.1	205	68.2
ORGANICS	**Method**	**DL**	**Units**			
Tetrachloroethene	OLM03.0	6-36	µg/kg	6 U	22 U	13 U
Trichloroethene	OLM03.0	6-36	µg/kg	6 U	22 U	13 U
cis-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	6 U	22 U	13 U
trans-1,2-Dichloroethene	OLM03.0	6-36	µg/kg	6 U	22 U	13 U
Vinyl Chloride	OLM03.0	12-72	µg/kg	12 U	44 U	25 U

Footnotes:

*: Unvalidated data.
**: Duplicate of sample LC12-SD201-01
DL: Detection limit.
mg/kg: milligrams per kilogram.
NA: Not analyzed.
µg/kg: micrograms per kilogram.
U: Analyte not detected above the sample detection limit.

Figures



LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 — MONITORING WELL INSTALLED BY FWES
- ESE-4 — UST MONITORING WELL INSTALLED BY ESE
- GEOPROBE LOCATION
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION

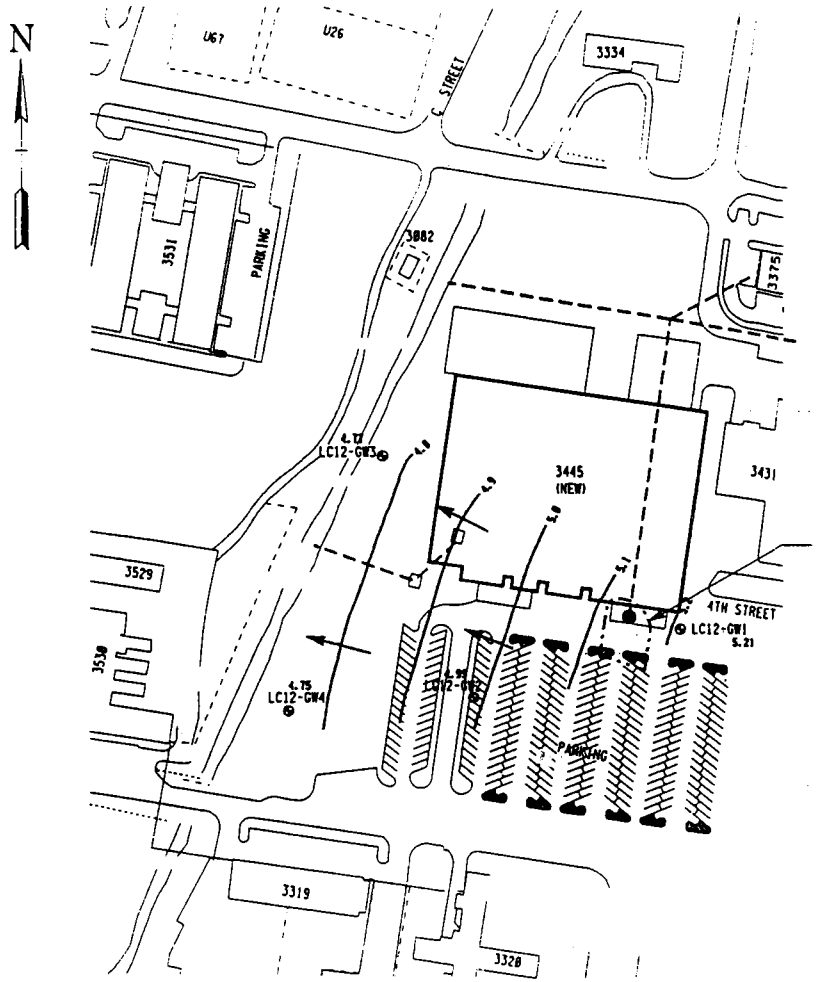
0 100' 200' 300'

1" = 200'

FIGURE 1
SAMPLING LOCATIONS
PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 2506f001.dlv



LEGEND

- 5.21 / LC12-GW1 — MONITORING WELL INSTALLED BY FWES WITH GROUNDWATER ELEVATION.
- 4.9 — LINE OF EQUAL GROUNDWATER ELEVATION
- GROUNDWATER FLOW DIRECTION
- SITE BOUNDARY
- FORMER WATER AND STORM SEWER LINE

GRAPHIC SCALE

0 150' 300' 450'

1" = 150' -0"

REV.	DATE	DESCRIPTION	APPR.
A	10-29-93	DRAFT TO LANTDIV	

REVISIONS

FIGURE 2

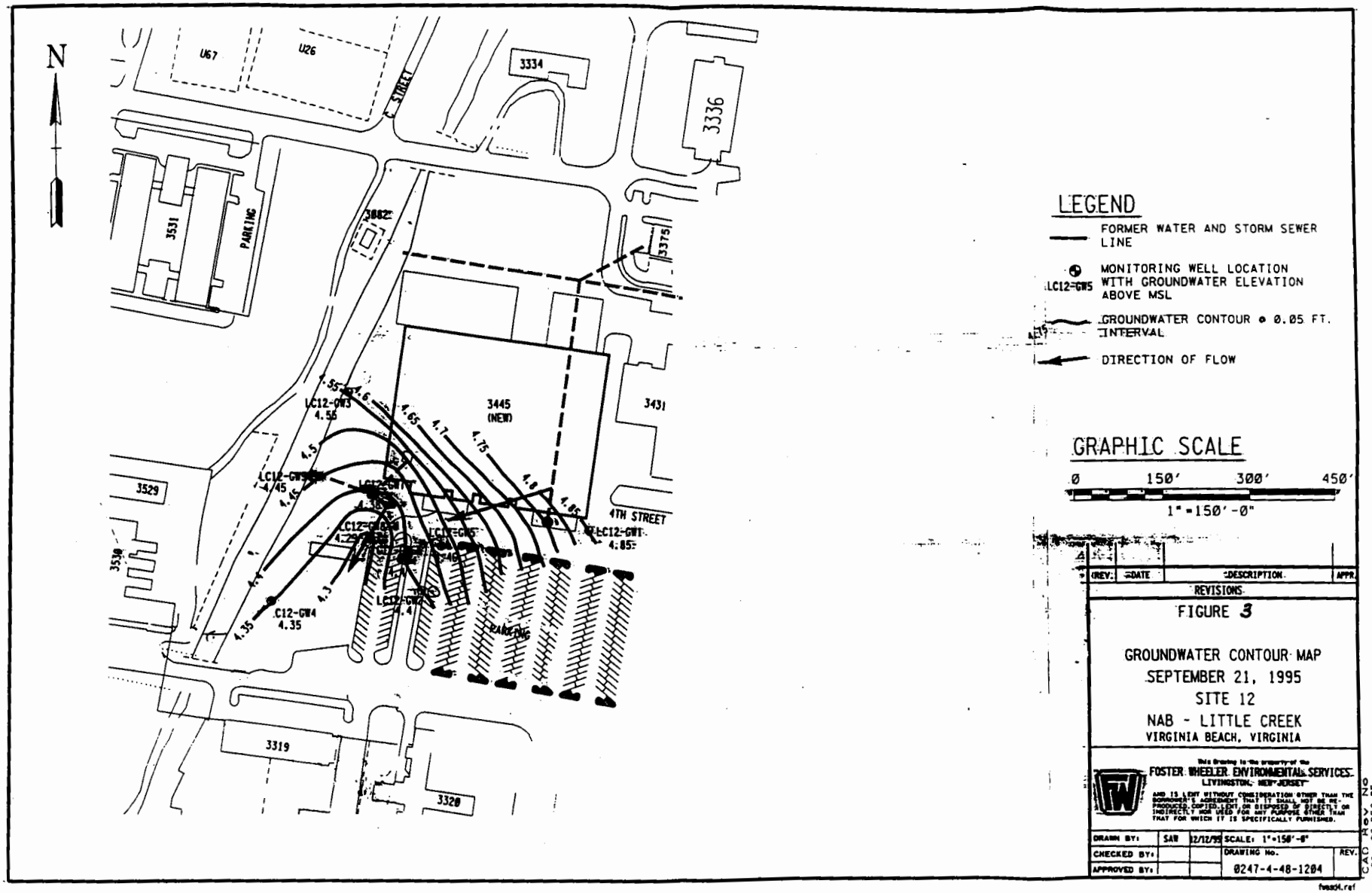
GROUNDWATER CONTOUR MAP
JUNE 28, 1993
SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

DRAWN BY:	SAW	10/11/93	SCALE: 1"=150'-0"
CHECKED BY:			DRAWING No. 192071-4-48-1230 REV. A
APPROVED BY:			

CAD Rev. No 01 27-OCT-93

FIES04.RDY

esd167810:71581238.dgn



LEGEND

- FORMER WATER AND STORM SEWER LINE
- LC12-GW5 — MONITORING WELL LOCATION WITH GROUNDWATER ELEVATION ABOVE MSL
- GROUNDWATER CONTOUR @ 0.05 FT. INTERVAL
- DIRECTION OF FLOW

GRAPHIC SCALE

0 150′ 300′ 450′

1" = 150′-0"

REV.	DATE	DESCRIPTION	APPR.
		REVISIONS	

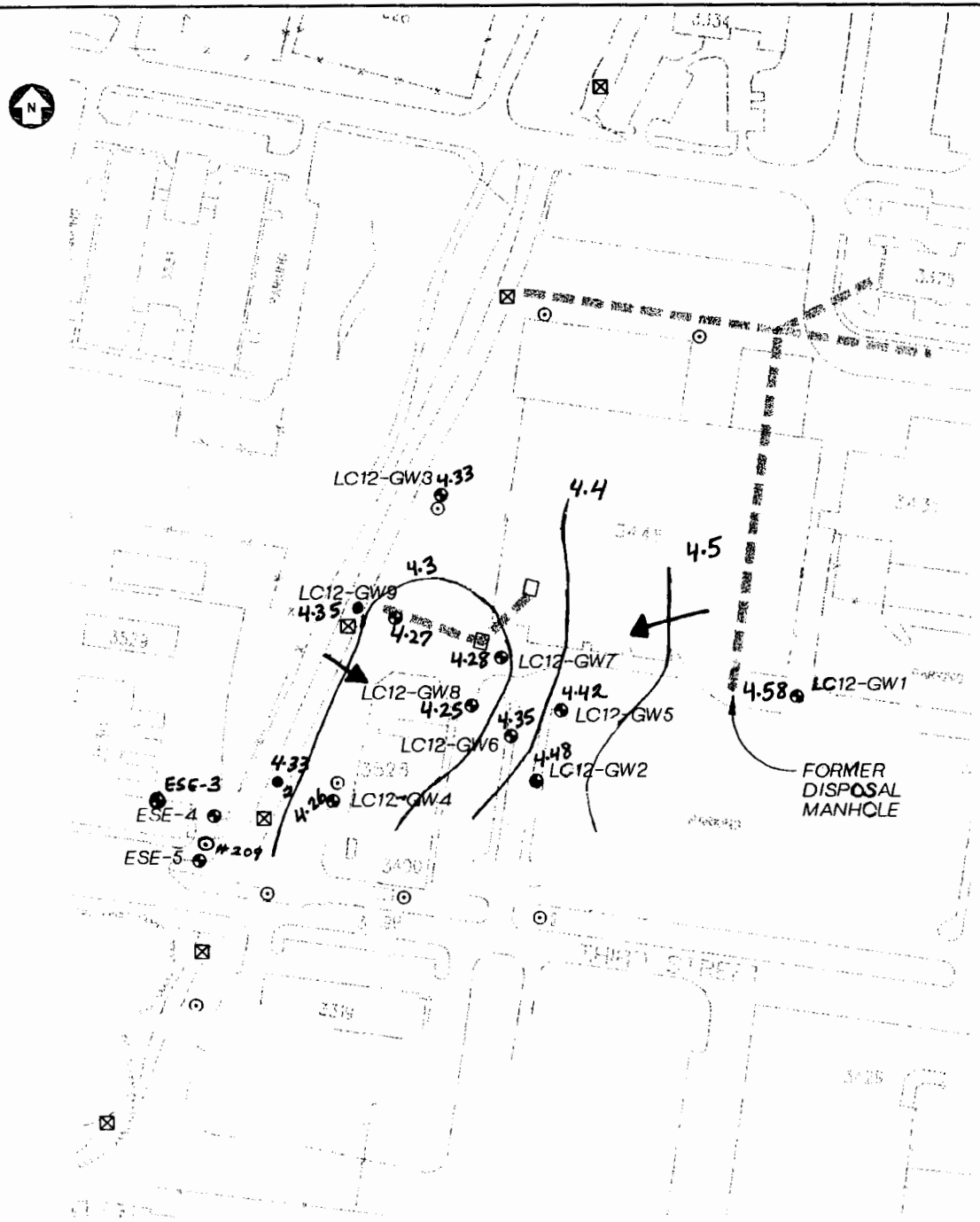
FIGURE 3

GROUNDWATER CONTOUR MAP
SEPTEMBER 21, 1995
SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

DRAWN BY:	SAR	12/12/95	SCALE: 1"=150'-0"	
CHECKED BY:			DRAWING No.	REV.
APPROVED BY:			0247-4-48-1204	

CAD Rev No 00 06-DEC-95

fwac4.ref



LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 4.58 — MONITORING WELL INSTALLED BY FWES WITH GROUNDWATER ELEVATION
- ESE-4 — UST MONITORING WELL INSTALLED BY ESE
- GEOPROBE LOCATION
- 1 — CREEK GAGING STATION (DATA LOGGERS)
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- 4.7 — LINE OF EQUAL GROUNDWATER ELEVATION
- GROUNDWATER FLOW DIRECTION

0 100' 200' 300'

1" = 200'

FIGURE 4
WATER LEVELS: SEPTEMBER, 1997
PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 25061001.dlv

FIGURE 5: Hydrograph: Southern Gaging Location

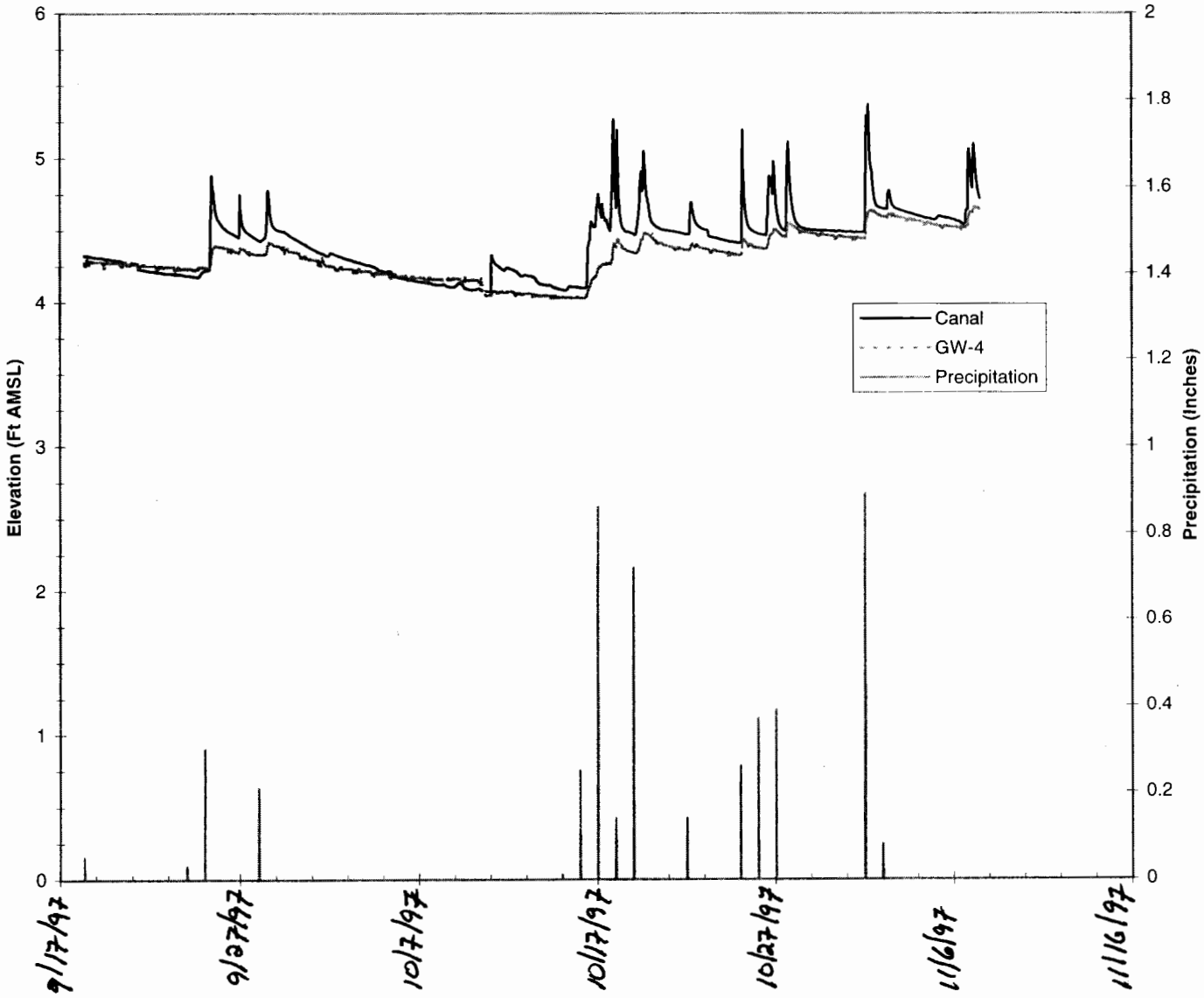
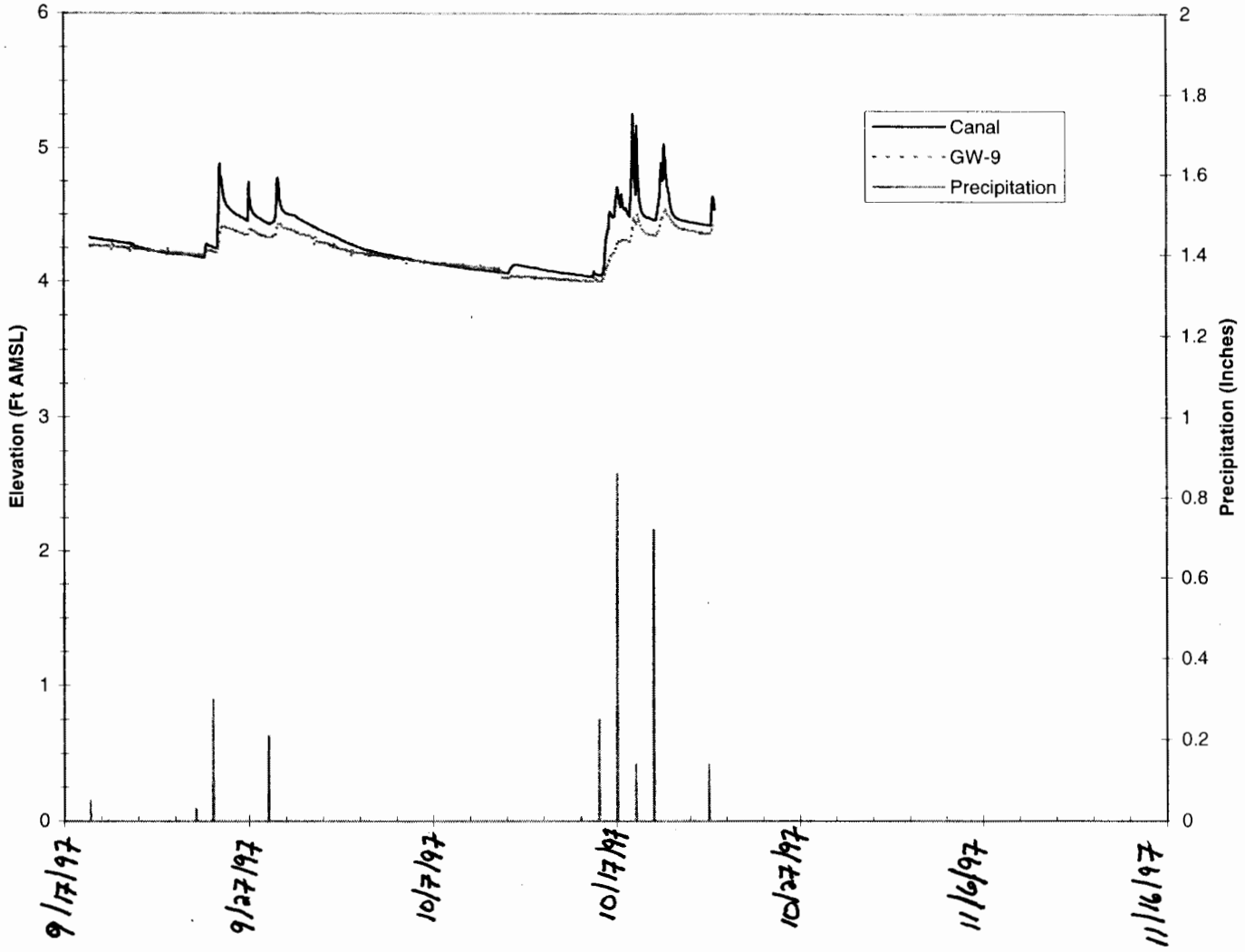
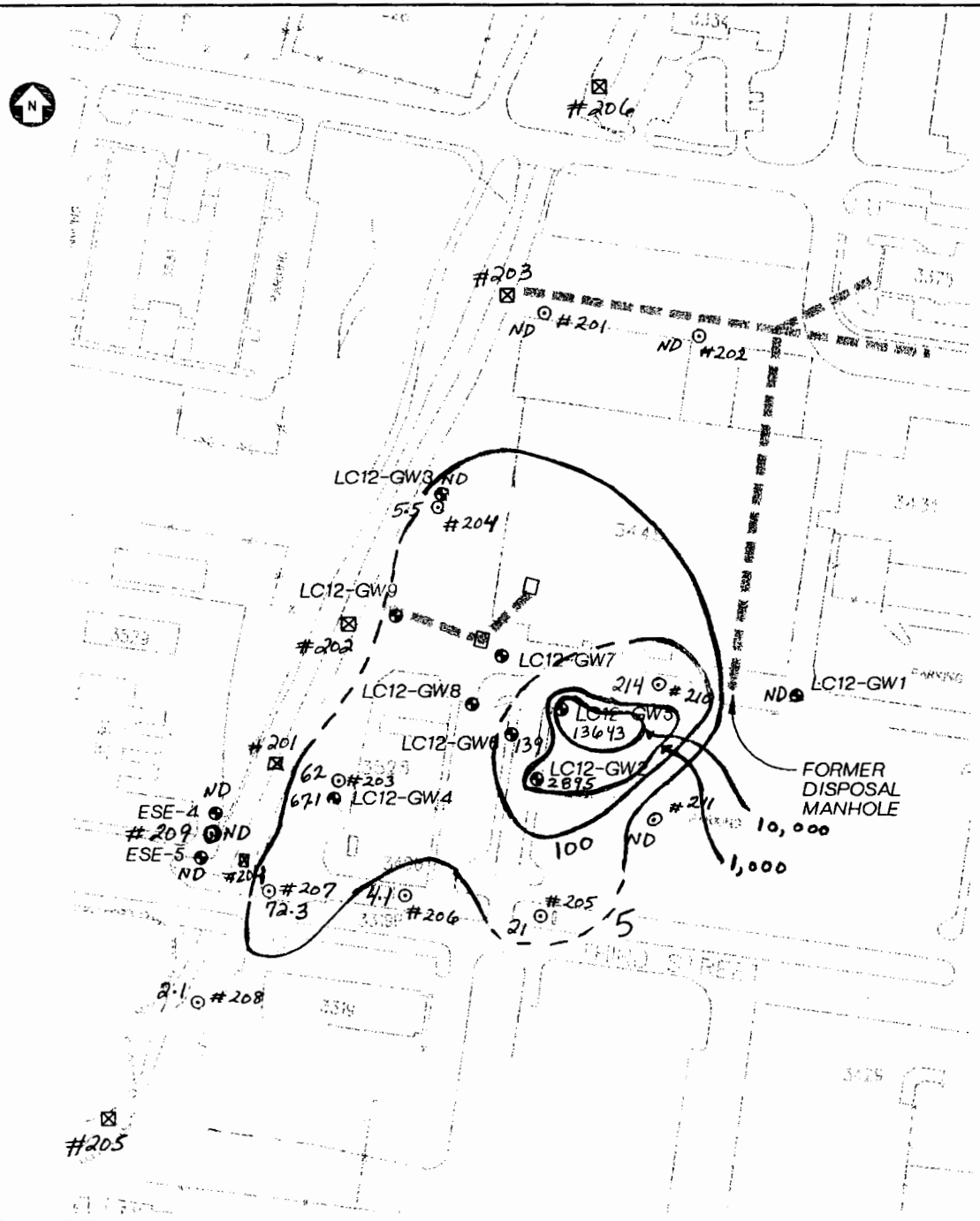


FIGURE 6: **Hydrograph: Northern Gaging Location**





LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 — MONITORING WELL INSTALLED BY FWES
- ESE-4 — UST MONITORING WELL INSTALLED BY ESE
- GEOPROBE LOCATION
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION

0 100' 200' 300'

1" = 200'

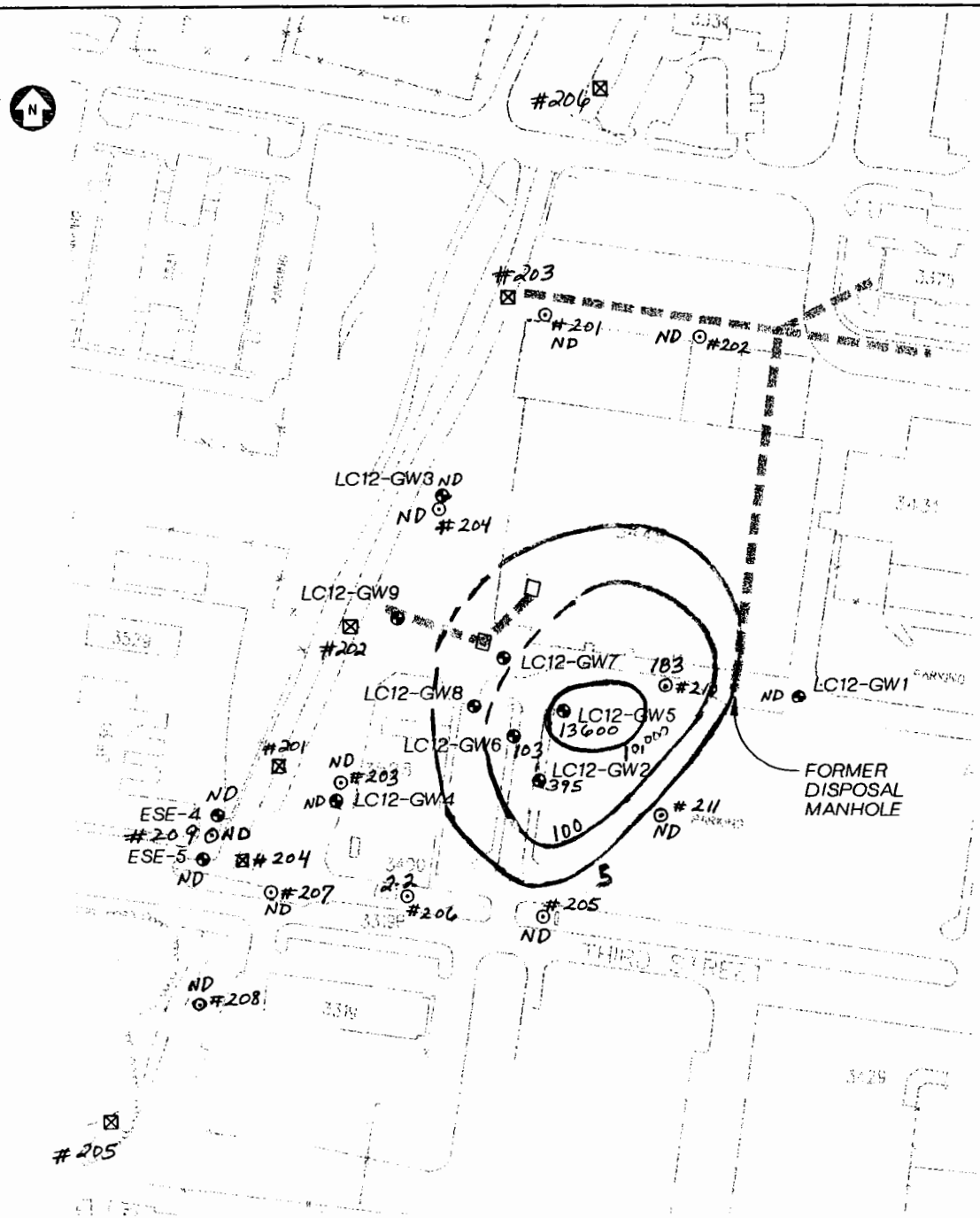
TOTAL VOLATILE HALOGENATED HYDROCARBONS IN GEOPROBE + WELL SAMPLES (ppb)

FIGURE 7

PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 2506f001.dlv



LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 ● MONITORING WELL INSTALLED BY FWES
- ESE-4 ● UST MONITORING WELL INSTALLED BY ESE
- ⊙ GEOPROBE LOCATION
- ⊠ SURFACE WATER AND SEDIMENT SAMPLE LOCATION

0 100' 200' 300'

1" = 200'

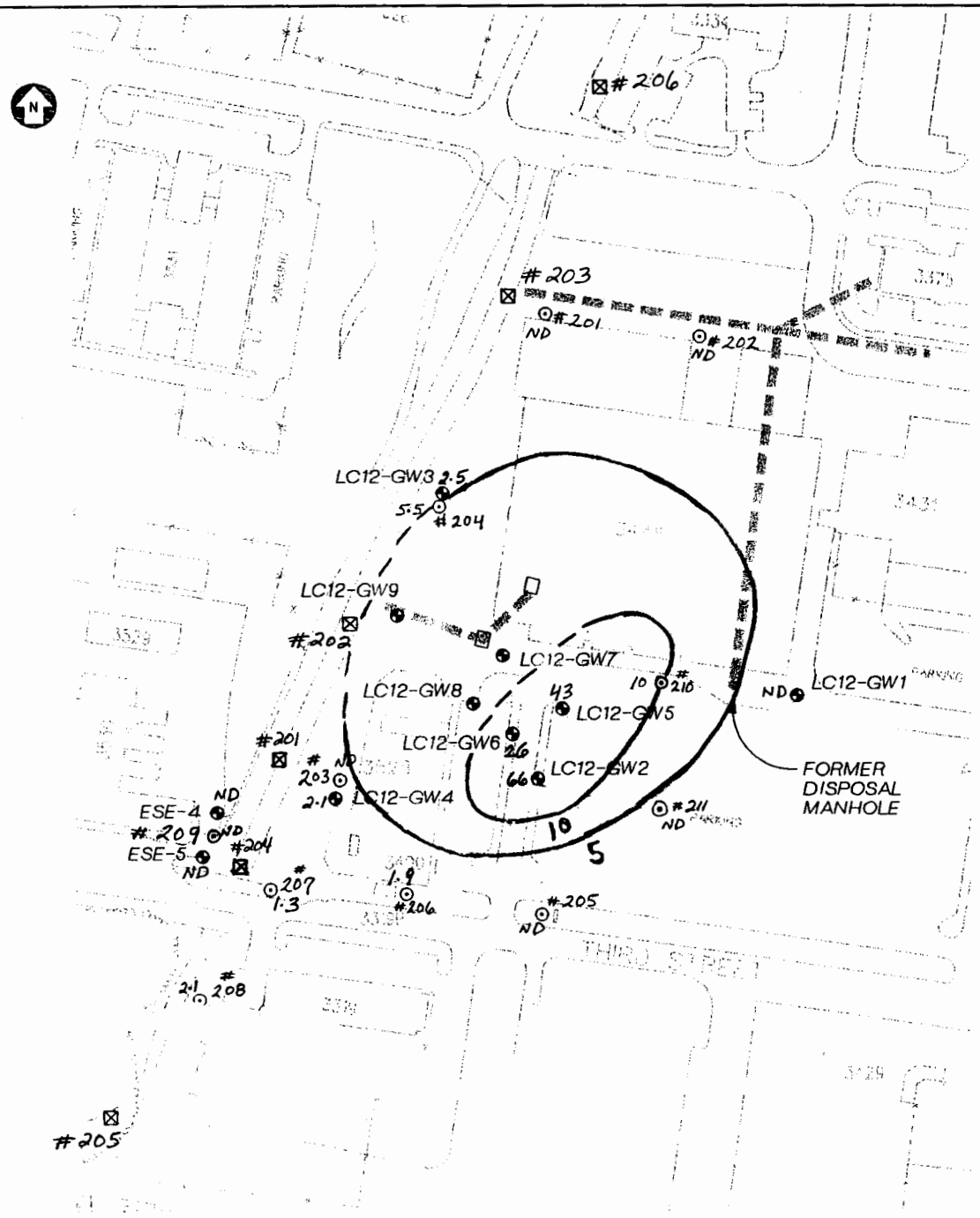
TETRACHLOROETHENE (PCE) IN WELL +GEOPROBE SAMPLES (ppb)

FIGURE 8

PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 2508f001.dlv



LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 ⊕ MONITORING WELL INSTALLED BY FWES
- ESE-4 ⊕ UST MONITORING WELL INSTALLED BY ESE
- ⊙ GEOPROBE LOCATION
- ⊠ SURFACE WATER AND SEDIMENT SAMPLE LOCATION

0 100' 200' 300'

1" = 200'

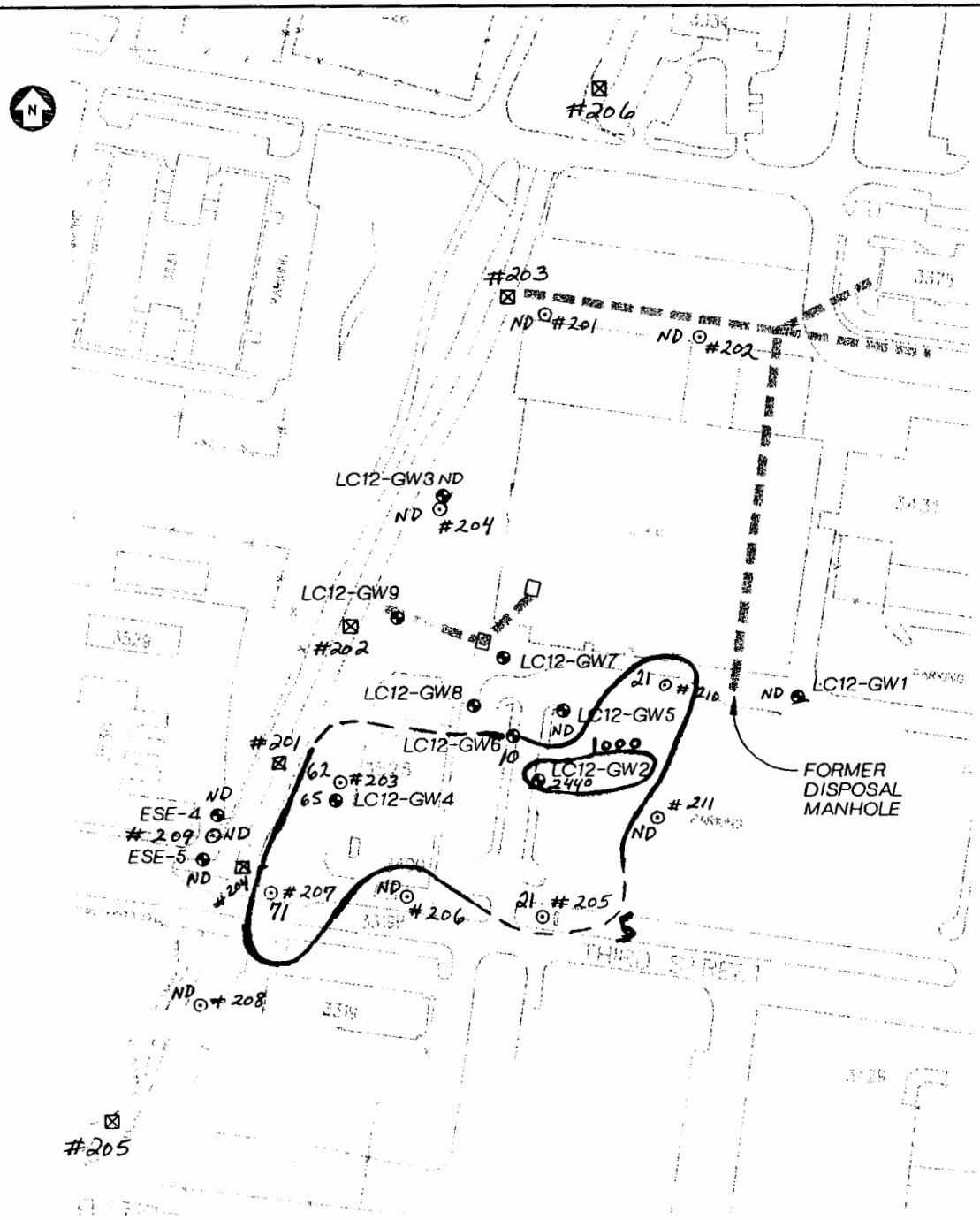
TRICHLOROETHENE (TCE) IN WELL AND GEOPROBE SAMPLES (ppb)

FIGURE 9

PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 2506f001.dlv



LEGEND

- FORMER STORM SEWER LINE
- LC12-GW1 ● MONITORING WELL INSTALLED BY FWES
- ESE-4 ● UST MONITORING WELL INSTALLED BY ESE
- ⊙ GEOPROBE LOCATION
- ⊠ SURFACE WATER AND SEDIMENT SAMPLE LOCATION

0 100' 200' 300'

1" = 200'

cis-1,2-DICHLOROETHENE IN WELL + GEO PROBE SAMPLES (ppb)

FIGURE 10

PHASE II SRI SITE 12
NAB - LITTLE CREEK
VIRGINIA BEACH, VIRGINIA

CH2MHILL

25-AUG-1997 2508f001.dlv

Appendix A
Field and Offsite Laboratory Data

FIELD LAB

DATA REPORT

VOLATILE HALOGENATED HYDROCARBON ANALYSIS OF WATER (EPA METHOD 8010)

CH2M HILL
625 HERNDON PARKWAY
HERNDON, VA 22070

NAB LITTLE CREEK, SITE 12

TEG PROJECT # 1-97382-A1

DATA REPORTED IN MICROGRAMS PER LITER (PPB)

DATE COLLECTED	—	10/8/97	10/7/97	10/8/97	10/7/97	10/7/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97
DATE ANALYZED	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97
SAMPLE ID	METHOD BLANK	LC-12 GW-6	LC-12 GW-2	LC-12 GW-4	LC-12 GW-1	LC-12 GW-3	LC-12 GP203-05	LC-12 GP207-05	LC-12 GP-207-10	LC-12 GP-206-05	LC-12 GP-206-10
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	111	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	740	ND	ND	ND	ND	18	17	ND	ND
CIS-1,2-DICHLOROETHENE	ND	10	2440	65	ND	ND	62	71	70	ND	ND
TRICHLOROETHENE (TCE)	ND	26	66	2.1	ND	2.5	ND	1.3	1.1	1.2	1.9
TETRACHLOROETHENE (PCE)	ND	103	395	ND	ND	ND	ND	ND	ND	ND	2.2
Surrogate Recovery (%)	88	127	104	129	86	102	101	102	95	100	137
Data Qualifiers											
Practical Quantitation Limit (PQL)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

"ND" INDICATES ANALYTE NOT DETECTED AT OR ABOVE LISTED PQL'S
DATA QUALIFIERS LEGEND APPEARS ON QA/QC DATA REPORT PAGE

ANALYSIS PERFORMED IN TEG'S CERTIFIED MOBILE LABORATORY
ANALYSIS PERFORMED BY: Mark Masino

FIELD LAB

DATA REPORT

VOLATILE HALOGENATED HYDROCARBON ANALYSIS OF WATER (EPA METHOD 8010)

CH2M HILL
625 HERNDON PARKWAY
HERNDON, VA 22070

NAB LITTLE CREEK, SITE 12

TEG PROJECT # 1-97382-A1

DATA REPORTED IN MICROGRAMS PER LITER (PPB)

DATE COLLECTED	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/9/97	10/9/97	10/9/97	10/9/97	10/9/97
DATE ANALYZED	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/8/97	10/9/97	10/9/97	10/9/97	10/9/97	10/9/97
	LC-12	LC-12	LC-12	LC-12	LC-12	LC-12	METHOD	LC-12	LC-12	LC-12	LC-12
SAMPLE ID	GP-208-05	GP-208-10	GP-210-05	GP-210-10	GP-205-05	GP-205-10	BLANK	GP-211-05	GP-211-10	GP-209-10	ESE-04
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	21	ND	16	21	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	1.7	2.1	2.2	10	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	183	ND	ND	ND	ND	ND	ND	ND	ND
Surrogate Recovery (%)	93	108	93	86	83	95	118	97	86	97	98
Data Qualifiers											
Practical Quantitation Limit (PQL)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

"ND" INDICATES ANALYTE NOT DETECTED AT OR ABOVE LISTED PQL'S
DATA QUALIFIERS LEGEND APPEARS ON QA/QC DATA REPORT PAGE

ANALYSIS PERFORMED IN TEG'S CERTIFIED MOBILE LABORATORY
ANALYSIS PERFORMED BY: Mark Masino

FIELD LAB

DATA REPORT

VOLATILE HALOGENATED HYDROCARBON ANALYSIS OF WATER (EPA METHOD 8010)

CH2M HILL
625 HERNDON PARKWAY
HERNDON, VA 22070

NAB LITTLE CREEK, SITE 12

TEG PROJECT # 1-97382-A1

DATA REPORTED IN MICROGRAMS PER LITER (PPB)

DATE COLLECTED	10/9/97	10/9/97	10/9/97	10/9/97	10/9/97
DATE ANALYZED	10/9/97	10/9/97	10/9/97	10/9/97	10/9/97
	LC-12	LC-12	LC-12	LC-12	LC-12
SAMPLE ID	ES-05	GP204-10	GW-05	GP-201-09	GP-202-09
VINYL CHLORIDE	ND	ND	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND
TRANS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE	ND	ND	ND	ND	ND
TRICHLOROETHENE (TCE)	ND	5.5	43	ND	ND
TETRACHLOROETHENE (PCE)	ND	ND	13600 d	ND	ND
Surrogate Recovery (%)	79	119	104	99	119
Data Qualifiers					
Practical Quantitation Limit (PQL)	1.0	1.0	1.0	1.0	1.0

"ND" INDICATES ANALYTE NOT DETECTED AT OR ABOVE LISTED PQL'S
DATA QUALIFIERS LEGEND APPEARS ON QA/QC DATA REPORT PAGE

ANALYSIS PERFORMED IN TEG'S CERTIFIED MOBILE LABORATORY
ANALYSIS PERFORMED BY: Mark Masino

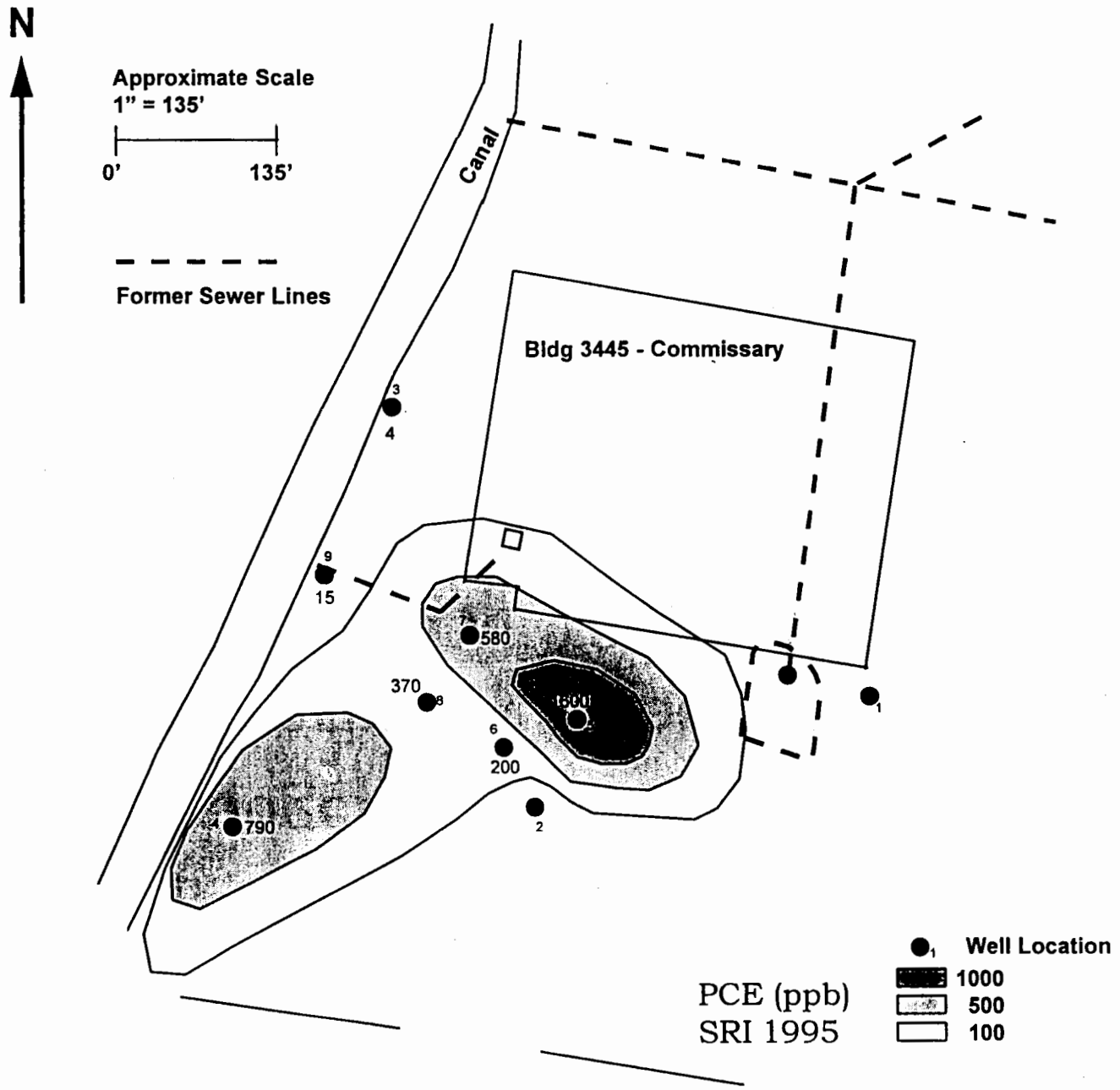
Confirmatory Analytical Results - Groundwater
Site 12-Exchange Laundry Waste Disposal Area
Naval Amphibious Base Little Creek
Virginia Beach, Virginia

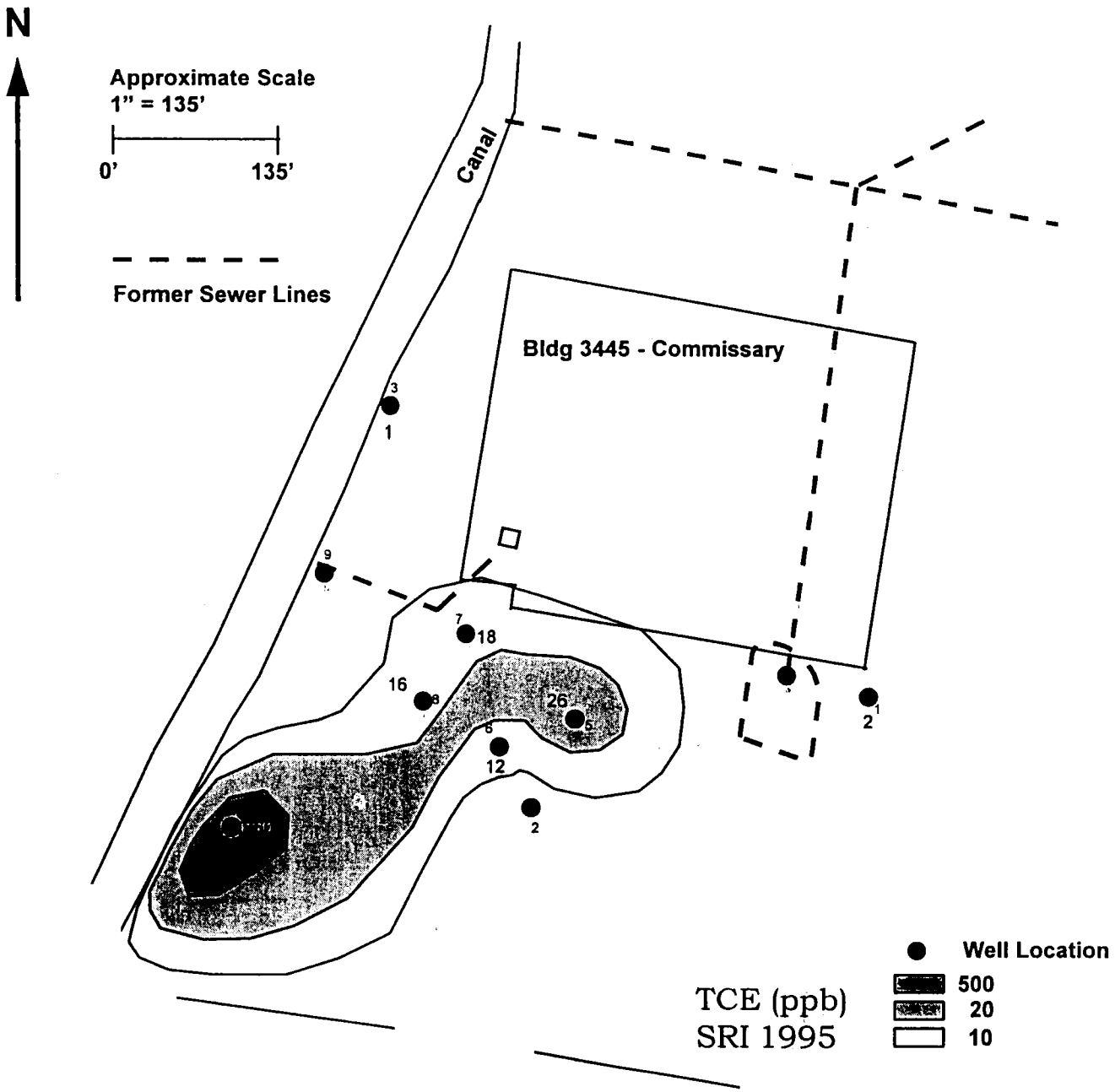
Sample Identification		LC-12 GP-201-09	LC-12 GP-202-09	LC-12 GP-205-05	LC-12 GP-210-05	LC-12 GP-211-05
Sample Collection Date		**8/95**	**8/95**	**8/95**	**8/95**	**8/95**
ORGANICS	**Units**					
Tetrachloroethene	µg/L	1 U	1 U	1 U	130	1 U
Trichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U
trans-1,2-Dichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U
Vinyl Chloride	µg/L	1 U	1 U	1 U	1 U	1 U

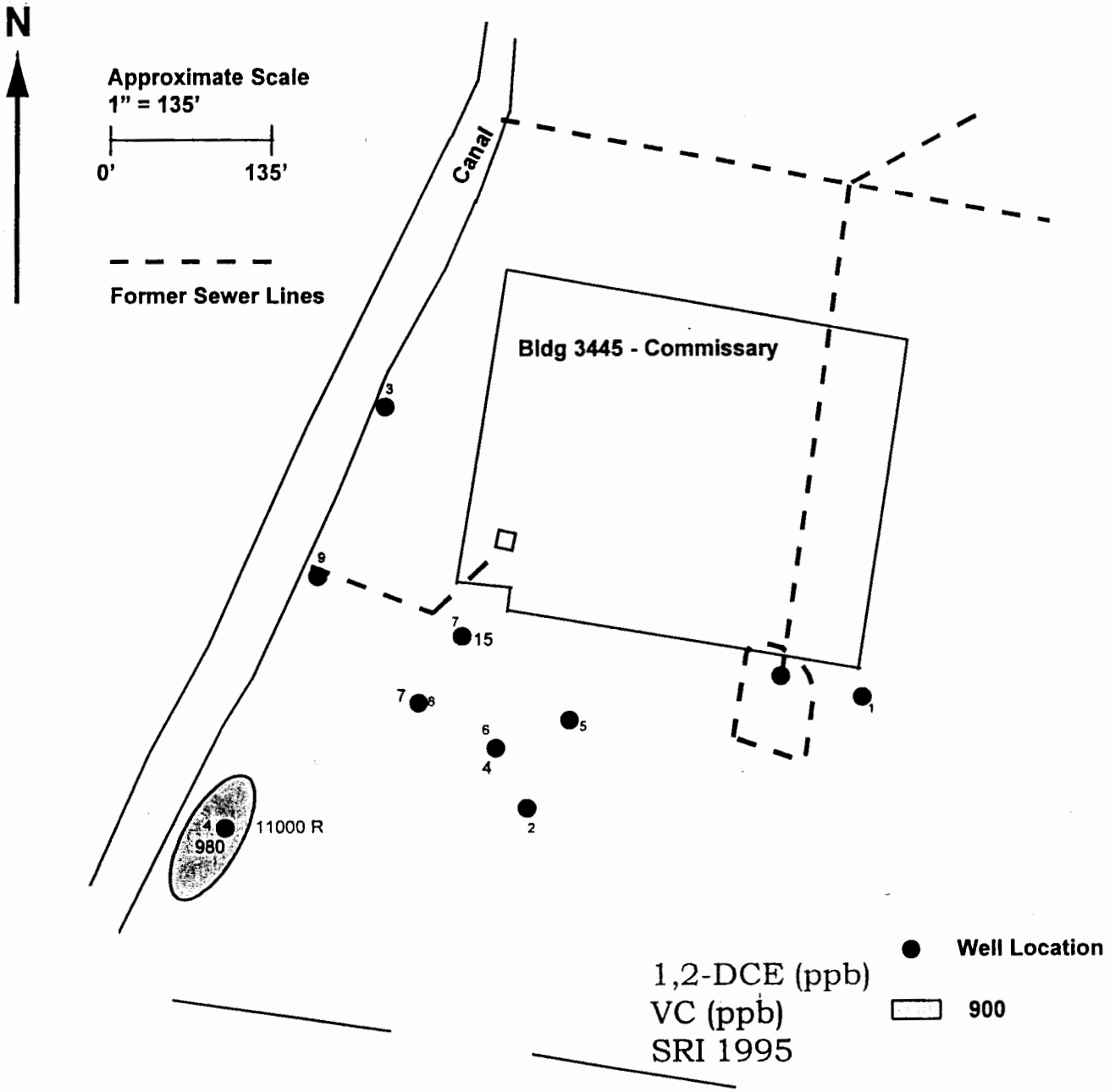
Footnotes:

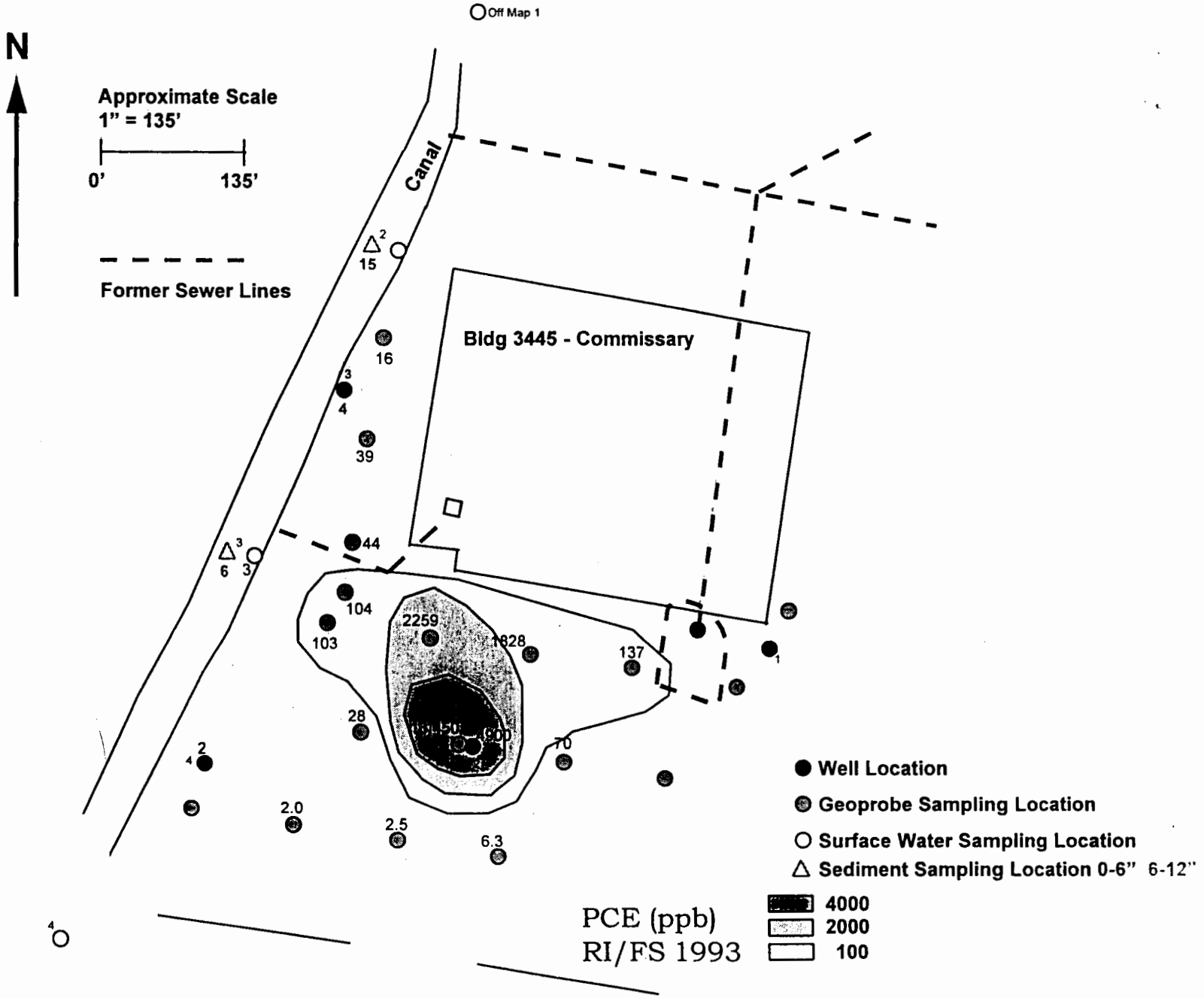
µg/L: micrograms per liter.
U: Compound not detected above detection limit.

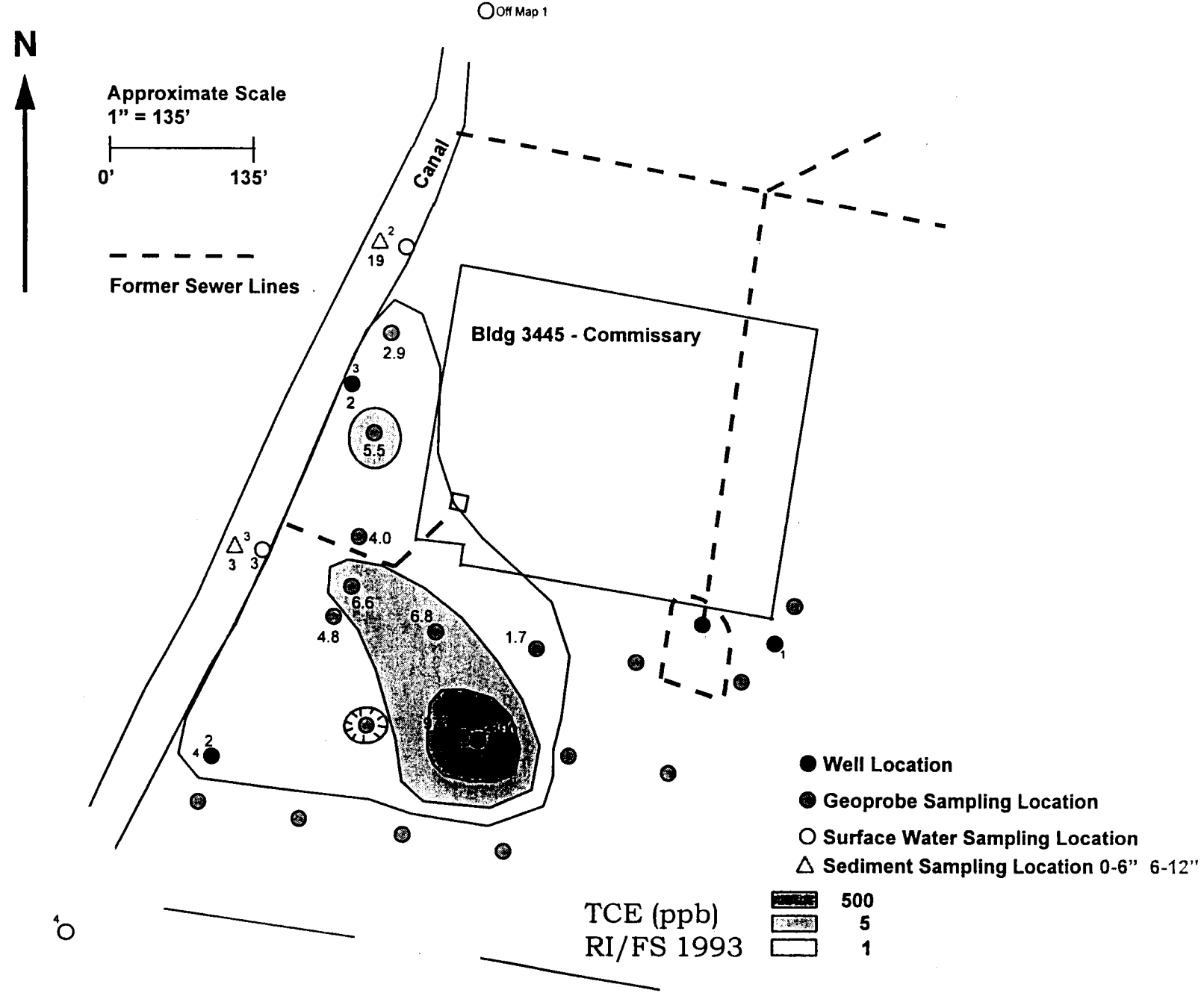
Appendix B
Historical Plume Maps

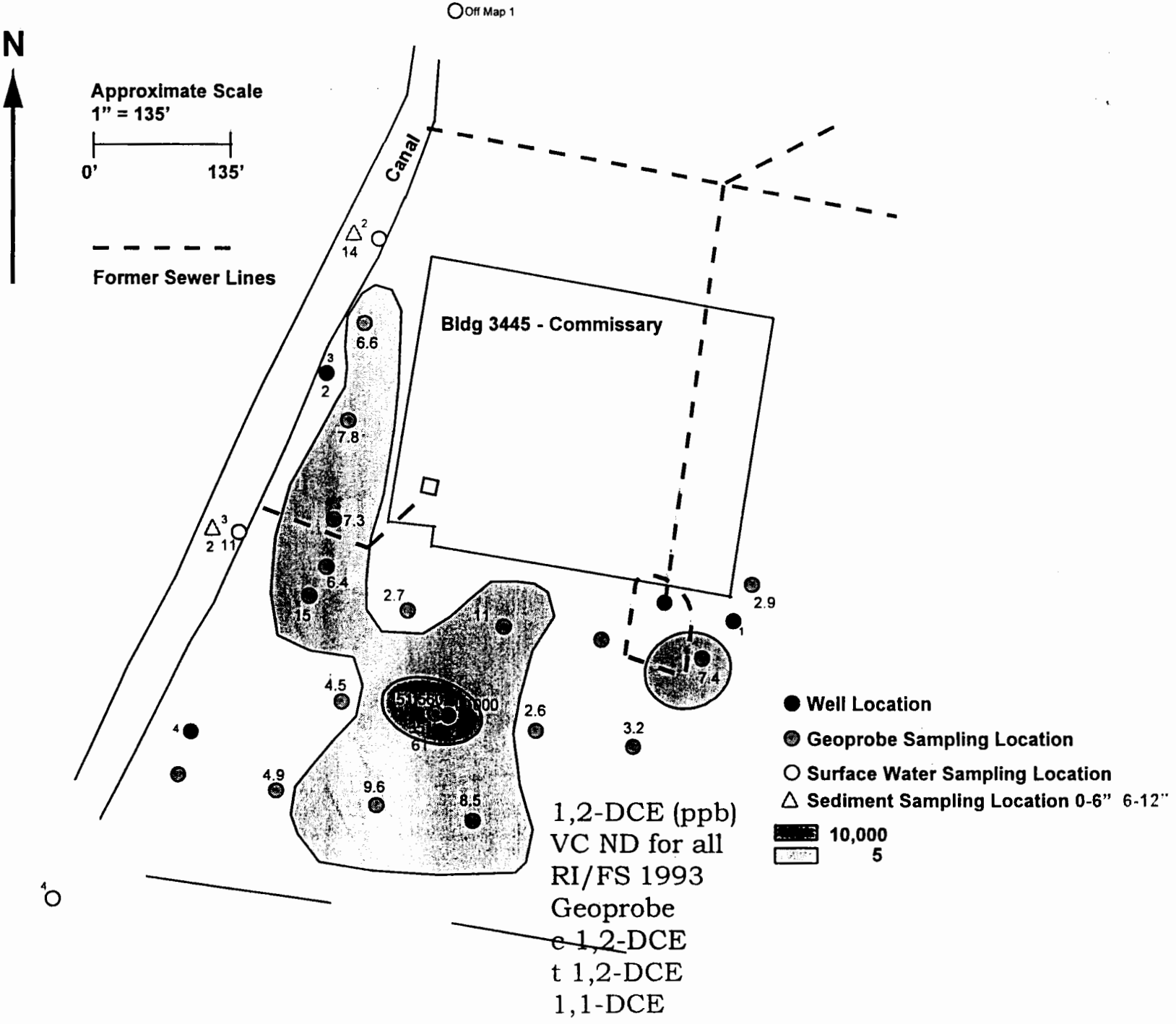

N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
3
4
9
15
7
580
370
8
1600
6
200
1
2
790
Well Location
1000
500
100
PCE (ppb)
SRI 1995

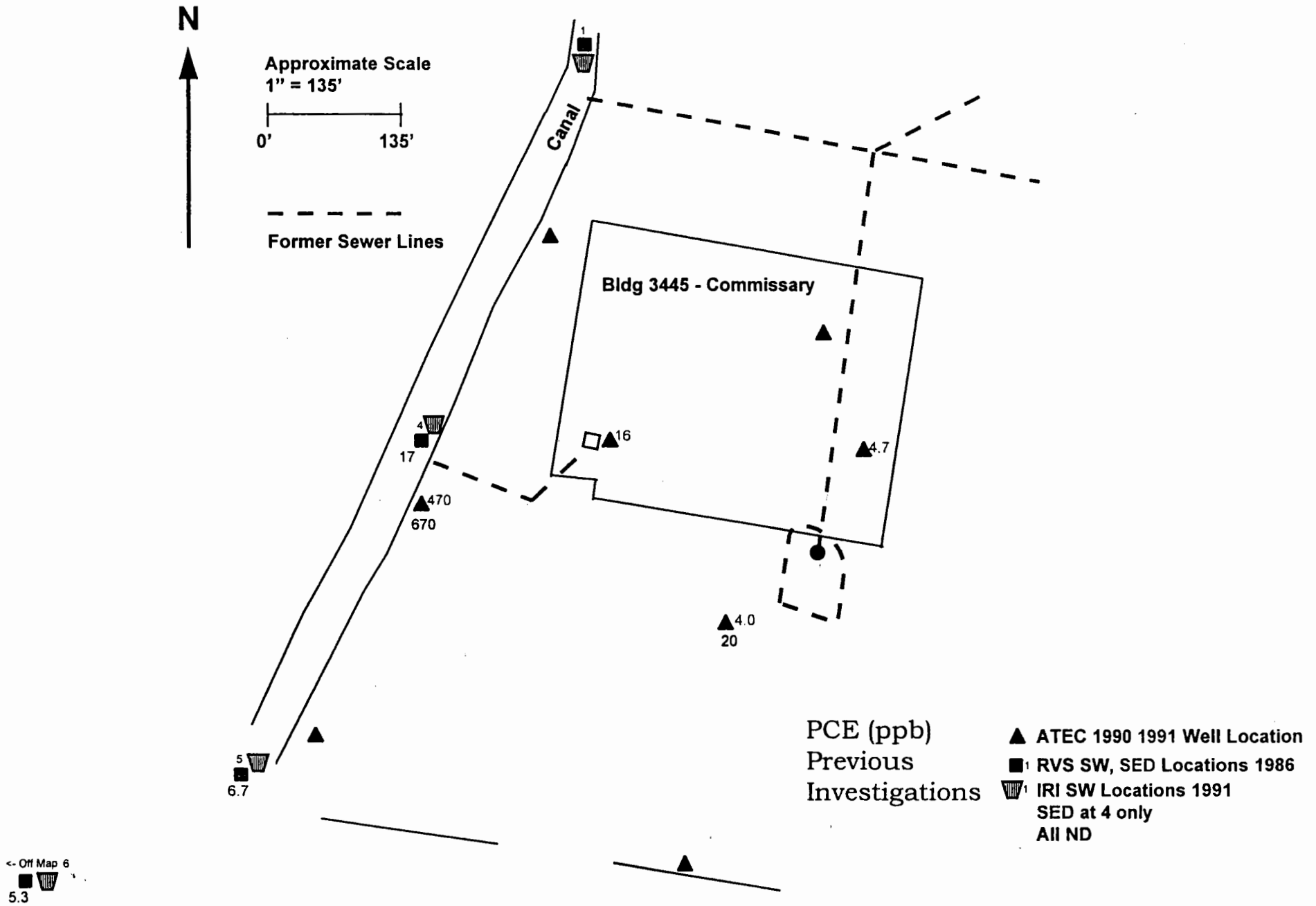

N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
3
1
9
7
18
16
8
26
5
6
12
2
2
1
Well Location
500
20
10
TCE (ppb)
SRI 1995

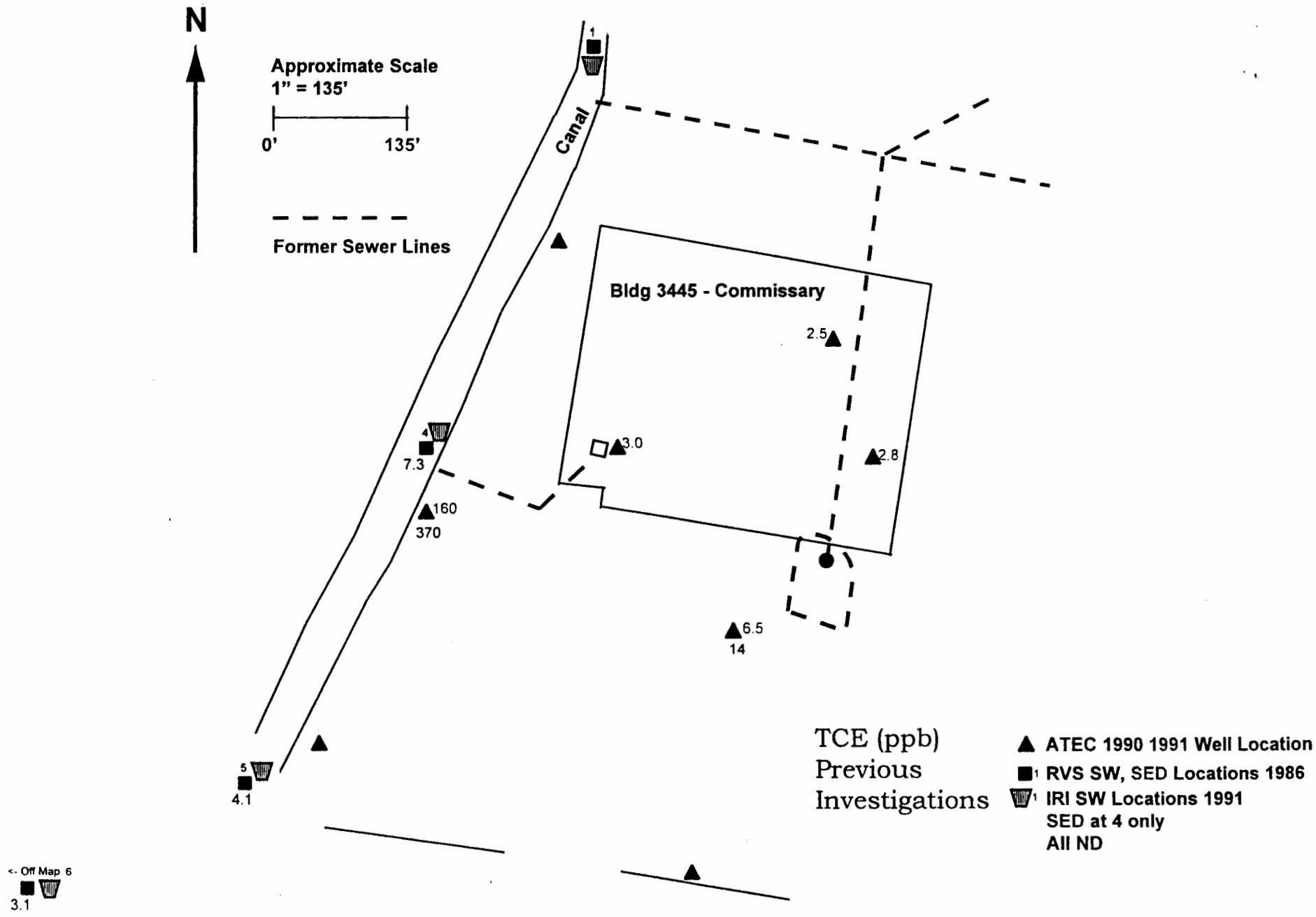

N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
3
9
7
15
7
8
6
5
4
2
1
4
980
11000 R
Well Location
1,2-DCE (ppb)
VC (ppb)
SRI 1995
900

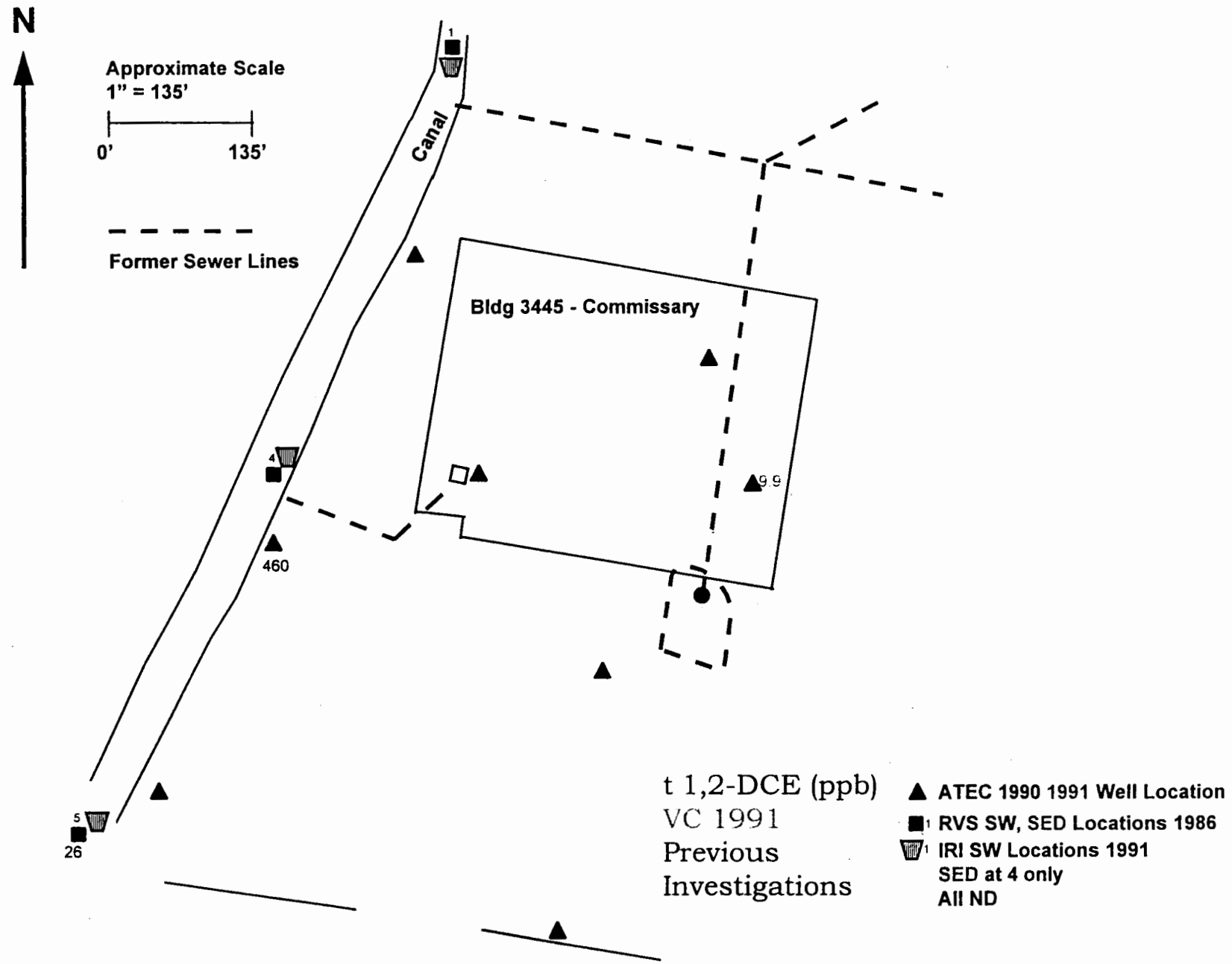

Off Map 1
N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
15
16
4
39
6
3
44
104
103
2259
1628
137
28
70
2
2.0
2.5
6.3
Well Location
Geoprobe Sampling Location
Surface Water Sampling Location
Sediment Sampling Location 0-6" 6-12"
PCE (ppb)
RI/FS 1993
4000
2000
100


Off Map 1
N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
19
2.9
2
5.5
4.0
6.6
6.8
4.8
1.7
Well Location
Geoprobe Sampling Location
Surface Water Sampling Location
Sediment Sampling Location 0-6" 6-12"
TCE (ppb)
RI/FS 1993
500
5
1


Off Map 1
N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
14
6.6
2
7.8
7.3
2 11
6.4
15
2.7
11
2.9
1
7.4
4.5
2.6
3.2
4
4.9
9.6
8.5
1,2-DCE (ppb)
VC ND for all
RI/FS 1993
Geoprobe
c 1,2-DCE
t 1,2-DCE
1,1-DCE
Well Location
Geoprobe Sampling Location
Surface Water Sampling Location
Sediment Sampling Location 0-6" 6-12"
10,000
5


N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
1
4
17
16
4.7
470
670
4.0
20
5
6.7
<- Off Map 6
5.3
PCE (ppb)
Previous
Investigations
ATEC 1990 1991 Well Location
RVS SW, SED Locations 1986
IRI SW Locations 1991
SED at 4 only
All ND


N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
1
2.5
4
7.3
3.0
2.8
160
370
6.5
14
5
4.1
<- Off Map 6
3.1
TCE (ppb)
Previous
Investigations
ATEC 1990 1991 Well Location
RVS SW, SED Locations 1986
IRI SW Locations 1991
SED at 4 only
All ND


N
Approximate Scale
1" = 135'
0'
135'
Former Sewer Lines
Canal
Bldg 3445 - Commissary
1
4
5
26
460
9.9
t 1,2-DCE (ppb)
VC 1991
Previous
Investigations
ATEC 1990 1991 Well Location
RVS SW, SED Locations 1986
IRI SW Locations 1991
SED at 4 only
All ND
<- Off Map 6
19 2.5
VC 2.9